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Perspective

Co-creation as a social process for unlocking sustainable heating transitions in Europe

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ABSTRACT

Providing heat is a key aspect of social life and a necessity for comfort and health in cold climates. Even though heat accounts for a large proportion of worldwide carbon emissions and is the largest energy end-use, it has remained largely untouched by efforts to decarbonize. Efforts to do so meet significant economic, social-psychological, technical and political challenges. Much is at stake. But what can make a difference? One increasingly discussed potential solution is co-creation. It provides spaces for citizens to share what heating means to them and for stakeholders to build these insights into their programmes for change. However, while local authorities, grassroots, and community organisations are already implementing co-creation with home-owners and groups of citizens, there is a dearth of academic research focusing on the value of co-creating sustainable heating transitions. This indicates a lack of evidence on how these new forms of collaboration perform under which conditions and how they are embedded in the policy cycle. Drawing on European sustainable heating case studies where co-creation has been applied, we outline future areas where critical, engaged research could help us to understand how to unlock sustainable heating transitions.

1. Introduction

Limiting global warming to 1.5 °C implies reaching global net zero CO_2 emissions around 2050 [1]. This can only be achieved by deep and rapid decarbonization of energy systems, including heating. Although sustainable heat consumption is expected to grow by 20% between 2018 and 2023, this growth would only increase the share of renewables in the heating sector to 12% in 2023 [2], leaving countries urgently needing to accelerate heat sector decarbonization to meet their climate change commitments [3].

Heating is a fundamental aspect of the human need for shelter in temperate climates and is a deeply embedded sociocultural and psychological as much as economic and technological phenomenon. Providing heat is a key aspect of social life (e.g. entertaining guests) and seasonal cultural practices (e.g. wintertime cosiness) [4]. Multiple factors make the transitions to sustainable heat challenging: heat demand in buildings varies immensely according to climate, building fabric, occupancy, and behaviour as well as issues around health, comfort, cost, control, convenience, and hospitality [5,6]. New heating technologies are perceived to offer no, or limited, additional consumer benefits compared to natural gas heating systems [7]. Residents, including tenants and homeowners are generally considered hard to reach and persuade [8,9]. Hesselink and Chappin [10] note that potential adopters of sustainable heating face barriers including high up-front costs, regulations, lack of information, as well as social and behavioural barriers such as trust, risk averseness, social comparison, and opinion dynamics. It goes without saying that those who are renting have no control over the building fabric.

At the international level, sustainable heating is absent from the United Nations' report on progress towards achieving the Sustainable Development Goals [11]. On the supply side, energy providers, national and local governments, local communities, resident associations, and individual homeowners (e.g. also in the form of 'prosumers') can all mix it up. Hence, heat markets are complex and fragmented, and generally less well understood than electricity markets [2]. As long as these markets are lucrative, path dependencies will complicate the transitions. Utility companies emphasize that they have to operate within the current regulatory and contractual framework, with an acceptable profit

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margin, giving them little space for deep transformations [12].

Over the last two decades, experiments actively involving citizens and stakeholders in the work of governments have become widespread. They have been accompanied by renewed academic interest in the concept of co-creation, building on work pioneered by Parks et al. [13] and Ostrom [14,15]. Yet despite its popularity in various disciplines, there is a lack of critical research that demonstrates or reflects on the connection between engagement and/or co-creation and its outcomes [16–18]. While the fields of participatory methods, citizen participation in sustainable heating, and the methodology of co-creation are growing [19–23], thus far there is little scholarly attention to the practice of co-creation with regard to sustainable heating systems.

This *Perspective* reviews the current literature on co-creation and sustainable heating transitions, and highlights the diversity of contexts, objectives, and practices of co-creation by presenting three illustrative case studies. A research agenda into co-creation in the specific context of sustainable heating is suggested. This addresses the need for critical research to better understand what heating means to local communities, tenants and homeowners,[1] how that meaning changes over time, and how practices of co-creation might build these insights into programmes of sustainable change. This will help us glean insights, facilitate our understanding, and explore the various promises and pitfalls of co-creation. Moreover, it could help unlock important mechanisms in the transitions to sustainable heating.

This *Perspective* uses a broad conceptual approach: heat transitions are conceived as an interdisciplinary problem involving sociotechnical processes. We focus on heat transitions in domestic settings in Europe. Sustainable heating here refers to the provision of heat from renewable sources, such as biomass, solar thermal, and green hydrogen[2]; stand-alone technologies such as air- or ground-source heat pumps; and larger-scale technologies such as district heating (DH) [24].

2. Socio-technical challenges

Sustainable heating transitions can be perceived through the lens of system innovation, i.e., the multi-level perspective [25]. Sustainable heating innovations develop and emerge from experiments at the niche level and are supported by various citizen movements that have mobilized and protest against the continued use of fossil fuel heating technologies [26]. Yet, such innovation movements may be confronted with regime barriers and incumbents who see their taken-for-granted position in the energy system as challenged, and who may seek to co-opt or eliminate the innovations [27,28]. Niche and regime, and their interactions, are subject to events at the level of sociotechnical landscapes (e.g., climate change, new government directives, major economic or political events) [25]. Sustainable transitions are not merely about the diffusion of new technologies, but also require change and eventual systematic breakdown of sociotechnical regimes. This requires change in user practices and cultural discourses that may cause broader political struggles [29].

Like other sociotechnical transitions, heating transitions will be *disruptive*, *contested*, and *non-linear* [30]. Implementing DH, for example, manifests a major change for the local energy market and related systemic elements like energy prices, user behaviour, and value chains. Moreover, DH reduces the autonomy of property owners and tenants, and binds them to a new, shared system. Setting up a sustainable DH system involves citizens not only as consumers, but as regulators and planners [22]. While conventional systems run on fossil fuels that are typically imported, sustainable systems run on locally provided heat and fuels. Table 1 provides a summary of the current literature on SH technology in domestic buildings alongside information on system barriers. This includes both electrical options to decarbonize heating [31] and other non-electric alternatives. Whereas electric options – using wind and solar PV-generated electricity – are considered by some as realistic, others hold that these scarce renewable energy sources can better be allocated to other sectors where they can yield more in terms of CO_2 reduction [32]. Table 1 presents stakeholder barriers that arise, which can potentially be addressed through co-creation.

3. Co-creation

The rationale for applying co-creation to sustainable heat transitions stems from the limited ability of authorities to cope with the increasing complexity of policy demands [46,47], disruptions in local heating markets [22], limited use of enforceable government policies in homes [9], increasing and relatively autonomous energy community movements [48], and the lack of progress in heat decarbonization compared to that made in decarbonizing electricity [2].

Co-creation starts from a fundamentally different place to the linear 'decide-announce-defend' practices of environmental policy change [50]. It is an iterative, reflexive approach that can be useful in mitigating climate change as it encourages interaction between citizens and stakeholders potentially providing a means of facilitating rapid and extensive transitions [51,52]. Fig. 1 illustrates how co-creation can be subdivided into process, community, level of application, and methods used. For example, co-creation can be perceived as a new social contract, where public officials take over civic roles and 'ordinary' citizens (community) take over public tasks, such as co-initiating, co-designing, or co-producing (process) public policies, services, communications, or infrastructures (levels) [18], by applying a range of tools or methods fit for purpose (methods).

Using co-creation can deepen understanding of how heat is used in-home [17,53] and prevent fragmented or suboptimal heating systems from happening [12]. Through exploring and exposing connected issues, knowledge, and ideas, co-creation can ultimately improve the quality of sustainable heating policy decisions [54–56]. Expanding the focus beyond carbon emissions, and adopting co-creation at scales ranging from street to neighbourhood and even municipality, may encourage better and mutually beneficial solutions that are considered more socially legitimate, more likely to be adopted, and more effective at meeting policy goals [57,58].

Co-creation draws on the concept of polycentric governance systems in which there are 'multiple, semi-autonomous decision-making centers' (p.928) [13,59] held together with effective mechanisms of coordination which resist fragmentation or centralization and which have the capacity to self-correct [60]. Co-creation originates from the business administration domain; however, important distinctions have to be made to apply the concept in the public sector context [49]. Within the process of co-creation, formal and informal rules, norms, values, strategies, and political values governing interactions are explored in supportive systems [14,61] which take processes of cooperation, competition, and conflict resolution into account in their communications [59]. Results from successful, deep sustainable heat transformations [61] show commonalities with co-creation approaches being rooted in: (1) equity and the dissemination of co-benefits, (2) inclusivity and local involvement, (3) information and innovation, (4) ownership and accountability, (5) organizational multiplicity, and (6) experimentation and flexibility. Other contextual factors can be expected to significantly influence possibilities for developing co-creation in sustainable heating transitions, such as formal institutions (e.g., grants, subsidies, or loans), informal institutions (e.g., tradition of cooperatives, civic engagement, or social capital), and other factors such as visions, narratives, and environmental education, can mobilize further resources and are supported through ambitious policy goals, regional planning, or social entrepreneurship [62]. These factors give co-creation in heat

[1] We acknowledge that both commercial and industrial buildings require significant heating, and that cooling is also an important issue, but these remain outside the scope of this article.

[2] Using renewable energy to generate electricity for electrolysing water to obtain hydrogen and oxygen.

Table 1
Summary of the current literature on sustainable heating (SH) in domestic buildings with technology type alongside system and stakeholder barriers.

Heating technology	System barriers	Stakeholder barriers
Biogas and green gas	Infrastructural challenges, high installation costs, high price of biogas production, environmental and safety risks, challenging regulatory framework with difficult permit systems [33].	High risk, many uncertainties, high transaction costs to biogas producers. Lack of political support and programmes to promote biogas technologies, lack of consumer interest [33]. Noise pollution, odour complaints [34].
Solar thermal systems	Limited resource potentials in Europe and lower price reductions than expected [35]. Bulky components and product potentials are limited. Uncertain and retroactive policies.	Legal and administrative delays leading to long wait times before deployment and increasing project delays cause problems for developers. Lack of social acceptability: land space requirements, change in building designs are met with resistance.
Hydrogen and fuel-cell heating systems	Current natural gas transmission infrastructure might not be suitable for hydrogen transportation, requiring dedicated pipelines. Fuel-cells are large and heavy compared to conventional boilers and have high installation costs [36]. Hydrogen is not yet applied to the built environment. It is an immature technical option in this sector.	Despite incumbent support for hydrogen pathways to heat decarbonization, policy support and investment remains in early, potential volatile stages of development [37].
Heat pumps	Noise pollution in densely populated areas. Technical difficulties related to building location and soil conditions for constructing ground source heat pumps [38]. Competitive low gas prices complicate the business case for homeowners [39].	Space constraints and environmental risks in urban areas [40] require willingness of municipalities and home-owners. Difficult because of high upfront investments required. Defensive strategy by gas incumbents: in order to protect sunk costs and remain competitive, decarbonization of the gas grid is actively supported, detracting from technologies like heat pumps, DH, etc., and slowing change [37].
District heating (DH) systems (discerning between those using residual heat from plants that use fossil fuels and those using renewable energy sources, in particular biomass, like organic waste or wood chips)	Prevalence of fossil fuel-based energy systems due to simultaneous evolution of technological and institutional processes leading to path dependent returns to scale [41]. DH systems do not have a competitive advantage over other sources like heat pumps or wood pellets, due to rising costs and ineffective pricing mechanisms [42].	Fragmented value chain requires cooperation of many stakeholders to support integration of DH: raises costs and risks [43]. Dependency on incumbent[3] actors: influence exerted by fossil fuel companies against policy-making supporting uptake of sustainable DH [44].
Decentralised combined heat and power (D-CHP) systems	Capital-intensive and long payback time [45].	Dependency of municipalities on incumbent actors: to integrate D-CHP into DH energy companies need to be provided with incentives to realise scaling-up [44]. For economic efficiency, cooperation between stakeholders at all levels is necessary to maximize CHP deployment [45]. Extant DH systems perceived as a barrier to scaling and integration of D-CHP.

[3]Incumbent actors are defined as those actors that already are in or have power in the existing regime (energy markets, business, government, etc.) in accordance with [34] and [27].

transitions a more Western European research focus, yet co-creation in general is increasingly receiving attention in Central and Eastern European countries [63,64].

Under the banner of co-creation, multiple and diverse methods have been adopted and deployed (see Table 2 and [54,65,66]). Table 2 illustrates the diversity of objectives, stakeholders, and methods, taken from real-world case studies, that have been used as co-creation in sustainable heating transitions. The role and value of including technical outcomes (e.g. CO_2 reduction), depends on the context and objectives of the project. Given the diversity of context, objectives, practices, and outcomes, evaluating 'successful' co-creation requires deeper understanding of the relationships between these elements. Without this, knowledge gaps will occur, pertaining not only to what counts as co-creation but also which methods work best and under which conditions.

4. Effective co-creation?

As seen in the case studies, there is much potential for infusing sustainable heating transitions with active residents and energy communities to cooperatively develop large- and small-scale sustainable heating projects. Co-creation approaches have potential to unlock sustainable heating transitions in Europe by providing spaces and collaborative partnerships that bring about necessary confrontations with local issues and co-benefits. In doing so, they are likely to unravel many of the supply and demand side complexities of sustainable heat that are currently locked-in. Yet co-creation is no panacea: nor is it tension free [72]. For it to be an effective process, a number of critical considerations are required.

For example, there is a danger of co-creation being used by policy-makers as window dressing rather than as a shift to sharing power and responsibility; powerful actors might embrace co-creation as long as it does not challenge the status quo. If critical political or business stakeholders are absent in co-creation, any results obtained might not be adopted in policy or planning procedures [73]. For example, many utility managers have expressed concerns and risks associated with co-creation, such as the additional work required to analyse and interpret the data, or the exposure to special interest activism which is not aligned with the service mandate of the utility firm. Moreover, they expressed a strong fear that initiatives resulting from co-creation activities would not achieve the level of rigour required for a regulatory process [74]. At the same time, inevitable disruptions in the heat transitions might not simply displace market leaders as disruption will also affect social housing, public services, and neighbourhoods [75]. Effective co-creation must strike a balance. It must allow transformation of existing heat systems to happen by minimizing any negative social effects.

Co-creation processes are further subject to self-regulation or self-made rules that influence issue selection, participants, information flow, or decision-mechanisms [76]. Therefore, the need for caution emerges around the risk of disenfranchising groups or segments of society. Co-creation processes are not exempt from attracting the 'usual suspects', that is, groups who have sufficient resources of their own and access to and experience with governmental collaborations. Attracting a motivated, self-interested, and unrepresentative elite might lead to unequal distribution of the costs and profits of sustainable heat. Moreover,

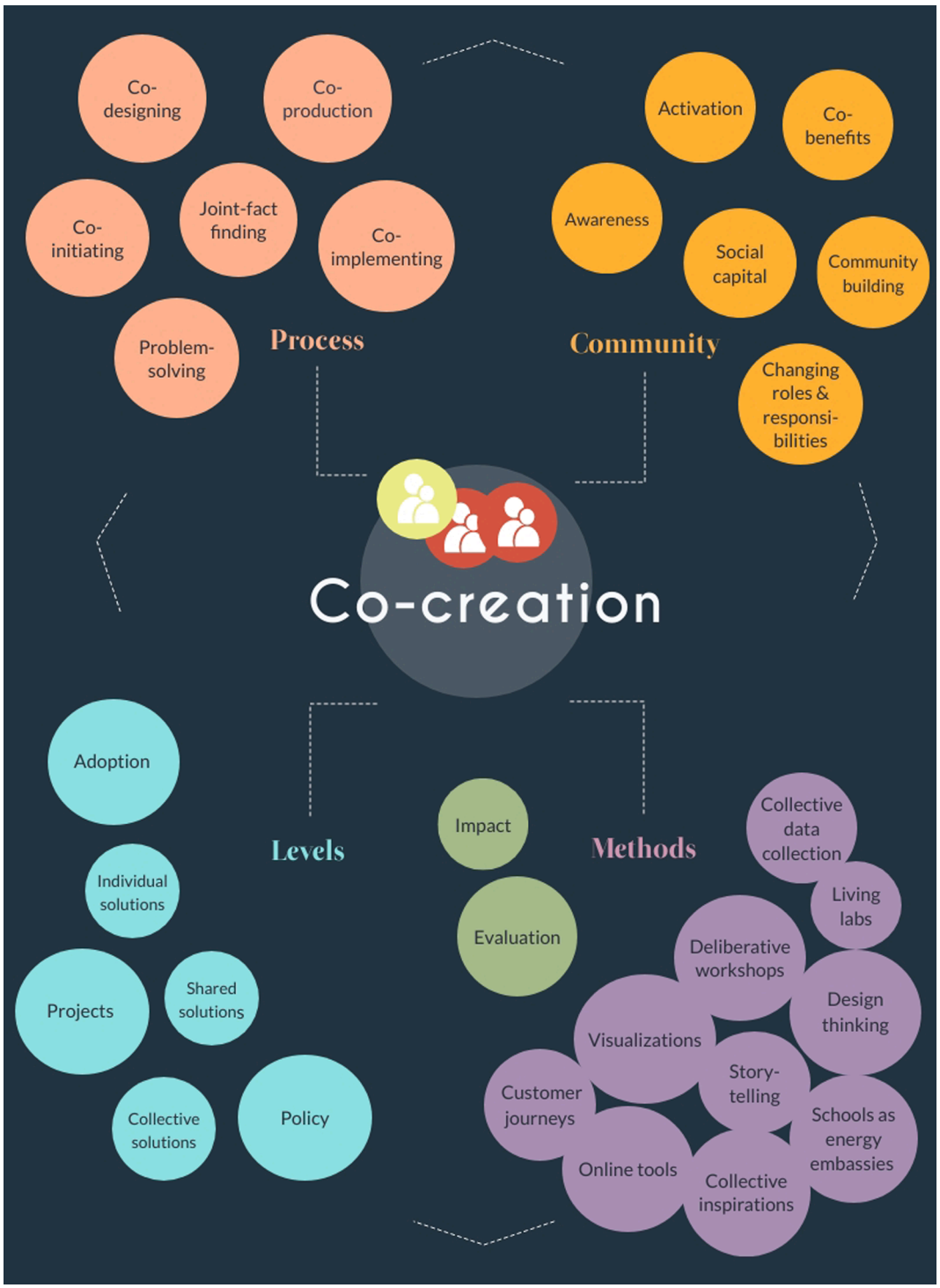

Fig. 1. Co-creation unravelled: process, community, levels, and methods [49].

co-creation has, in some cases, led to fuzzy outcomes or hijacking of the process [77].

These tensions make a current misfit for effective co-creation obvious: on the one hand policy-makers struggle with integrating social issues that flow upstream into policy cycles before they have become of broad public concern. Without a significant push or demand in society to replace outdated fossil fuel heating systems, politicians are unlikely to act [67,68]. On the other hand, citizens struggle with institutions that seek to predefine or modify topics to achieve instrumental ends. For example, citizen initiatives which focus on a different approach for achieving sustainable heating than a governmental approach, might be sceptical to engage in co-creation [72]. Or, as shown in another case, the enactment of co-creation showed that people resisted being forced to change their habits if they felt it was being pushed onto them [78]. Policy-makers often prefer structured citizen participation in order to further their mandates, gain popular support, achieve high levels of adoption, or enhance legitimacy for technological advance [79]. On top of that, public administrations may have concerns that they lack capacity or would have to abandon some degree of control of the process leading to procedural mistakes or unwilling precedents [80].

Table 2
Comparison of three case studies illustrating different approaches to co-creation in sustainable heating transitions. More detail on each case study as well as number of additional examples are available in the supplementary material.

Case study	Objective	Co-creation practice	Stakeholders	Outcome/s
Hamburg, Germany. Initiated by citizens (local residents) and led by local government. [67,68]	A citizens' (local residents) initiative organized a referendum to return privately-owned heating, gas, and electricity grid infrastructure to public ownership (although at high financial costs).	Citizens (local residents) co-initiating and, eventually, local administration taking a public leadership role using agency to reclaim incumbent-controlled energy infrastructure with the aim to use it more democratically and eventually distribute more sustainable energy. At the same time, a new citizens cooperative operates its own decentralized energy generation plant in order to produce and market renewable electricity and heat.	Citizens (local residents) Local government Three 100% publicly owned grid companies for gas, heating and electricity. Citizens cooperative EnergieNetz Hamburg eG.	All grids (electricity, gas, and heating) were transferred to public ownership. As an initial outcome of the so called re-municipalisation, the publicly owned company will reduce its use of coal by 20% immediately and by at least 30% per year from 2023. This corresponds to around 150,000 tonnes of coal per year. Also regarding the gas grid, the publicly owned company intends to significantly switch the focus from natural gas to biogas and hydrogen technology.
Delft, the Netherlands. Led by local government. [69]	Development of a neighbourhood-level plan for sustainable heat to replace natural gas.	Information and discussion meetings identified starting points for the heat plan and which actions should be taken and when. Creating a community platform to co-create sustainable heating policy and neighbourhood options. Creating an overview of technical details of buildings in Delft including: energy consumption, building age and insulation status, monument status, suitability of roofs for solar panels, space for heat pumps.	Local government Citizens (local residents) of Delft	Meetings gave citizens (local residents) space to say what was important to them and voice concerns. Co-creation defined the scale of the involvement of residents in the sustainable heating transition plan of the municipality. Created a sense of community around energy policy. Created a socially legitimate approach to sustainable heating.
Thermo Bello, the Netherlands. Led by citizens (local residents). [70,71]	To develop a small-scale power-to-heat DH system (2500 MWh annual production).	Creating a heating cooperative for residents to join. Establishing a business development committee with four working groups who worked on feasibility studies and business plans. Presenting the plans to the wider community. Conducting regular surveys monitoring resident satisfaction and support for the project.	Neighbourhood residents Local government Residents association Previous network heating owners	Transparent business case developed for the DH system. Technical design was part of the neighbourhood process that was developed. Thermo Bello took over an existing, privately-owned heating network. Thermo Bello started delivering low-temperature water for space heating to neighbourhood residents in 2009. Established partnership with local government and supporting organisations.

Creating a recognisable signature for co-creation, which integrates divergent visions and promotes equity and integrity between citizens and authorities, requires that co-creation seeks to bring together citizens and stakeholders with diverse perspectives [81] at an early stage of developing sustainable heating policies or projects, to provide inclusive spaces where all perspectives are welcome. Moreover, it requires a just distribution of co-benefits [61] to prevent co-creation being a process reserved for the 'happy few' and to allow disadvantaged communities to profit equally from sustainable heating transitions. By 'taking a step back' and letting citizens define what is important to them [82], public officials can create opportunities for building trust [56]. Lastly, co-creation needs to connect to the 'political stream' [83] and be supported by clear political commitment without which it may be difficult for individual members of the community to step up to leadership roles. This in turn needs an environment in which inevitable disruptions and conflicts can be managed and facilitated [84].

5. Conclusion and suggestions for future research

Although heat accounts for a large proportion of worldwide carbon emissions, to date it has remained largely untouched by efforts to decarbonize [85]. Reaching global net zero CO_2 emissions can only be achieved by deep and rapid transitions to sustainable heating. Yet the transformation to sustainable heat constitutes a wicked problem [1]. While local authorities, grassroots, and community organisations have begun to tackle this problem through co-creation, academic research has been slow to focus on this topic. Co-creation should not be seen as a cure-all approach, and is only one option to foster sustainable heating. Strong political–administrative interventions with the pursuit of efficiency at all costs might also achieve cleaner heating [86], but it is doubtful if such approaches centrally focus on renewable energy sources in heating systems, or just replace heating energy from coal with natural gas. Moreover, in light of previous findings on sustainable heating transitions [61], such rigid top-down approaches might fail in the long run since they do not place much trust in achieving co-benefits, involving citizens, or promoting shared ownership. Hence, such approaches are not the focus of this *Perspective*.

Co-creation requires handling with great care when implemented. It entails a complex process with many caveats and possible pitfalls. Given that there has been very little critical developmental and evaluative research on co-creation thus far [16,18], we begin to formulate a research agenda for the use of co-creation in sustainable heating by specifying the following research questions (without claiming completeness):

- As a basic start, we suggest tracking what is happening around the world under the name of co-creation and sustainable heating. How is

co-creation constructed? Which actors are involved and in which roles? What outcomes have been achieved?

- Research could tackle how co-creation, and its various methods, have been and can be deployed in sustainable heating transitions, with suggestions on how to conceptualize, operationalize, monitor, and evaluate specific case studies.
- Comparison of different sustainable heating case studies could identify contextual variables that accelerate or slow co-creation processes. Comparative studies would also allow better visualization of the critical junctures of change as well as rebound effects.
- While observing heat transitions over time, not only the increasing diversity and variety of approaches, including their pros and cons, should be researched, but also their eventual consolidation and decline. Will co-creation disappear or succumb to external forces? This should be traced and observed.
- Observation over time would also enable better understanding of the evolution or path dependency of co-creation. Questions could be asked on how power relations between authorities, businesses, or citizens change, or if one stakeholder predominates.
- Agents of change may act to facilitate sustainable heating transitions. Here, besides studying grassroots organisations and energy collectives engaged in sustainable heat, we suggest analysing the role of researchers in co-creation. If citizens and local authorities change their roles once they become involved in co-creation, do researchers change as well? With what outcomes?
- There has been an increase in studies on online participation and deliberation as democratic innovations, and not only since Covid-19. However, since co-creation is substantially different, and predominantly exercised through physical practices, it is crucial to study the potential and pitfalls of digital co-creation for sustainable heating.

We invite stakeholders, citizens, and researchers from other disciplines to adopt these research questions, develop research projects, and particularly encourage research into co-creation with diverse communities [23].

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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